Topology optimization of super hydrophobic surfaces: design and fabrication

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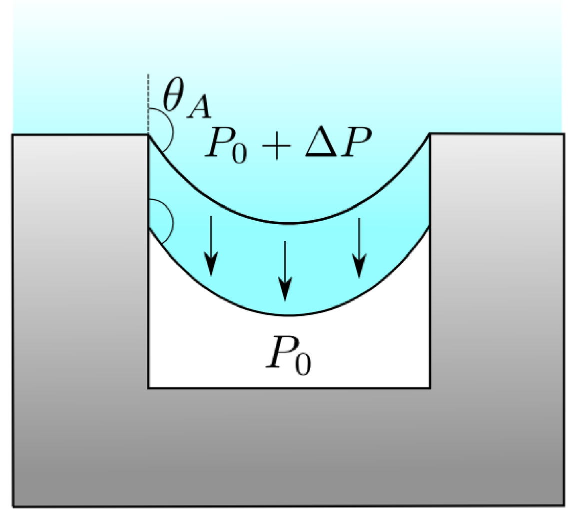
Topology Optimization

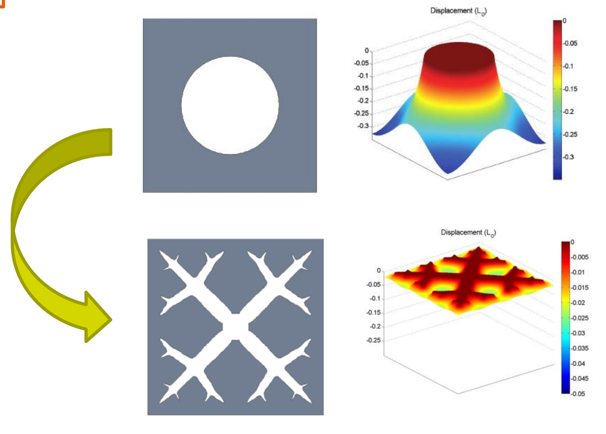
Collapse of the Cassie State

Super hydrophobic surfaces is usually associated with the so called Cassie state, where a drop rests atop of asperities. The Cassie Baxter state is often just a metastable state where the wetting state, called Wenzel state, is the energetically favorable. The transition from the Cassie state to the Wenzel state is often hindered by an energy barrier, this energy barrier can be overcome by an applied pressure to the drop.



Topology Optimization

Topology optimization is a free shape optimization routine already applied with success in several areas of science and engineering. We use it here to find the optimal cross section for a micrometric post, in order to minimize the displacement of the liquid-air interface under applied pressure [1]. This should improve the robustness of the suspended Cassie state, and make the patterned substrate super hydrophobic under a wide range of working conditions.

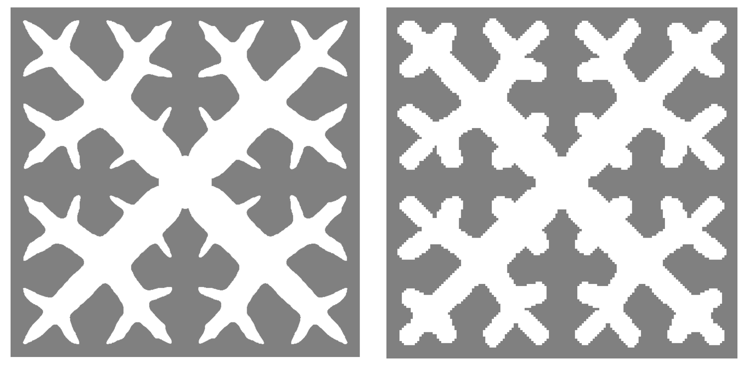


[1] A. Cavalli, P. Bøggild and F. Okkels, Soft Matter, 2013, 9, 2234

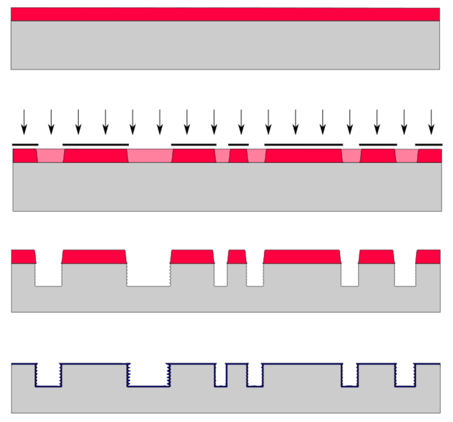
Fabrication

Post Processing of Topology Optimized Structures

Post processing of the calculated structures are necessary to reduce the difference in length scale of topology optimized structure. The post processing algorithm ensures dilation of narrow parts without changing the overall structure.



Fabrication Process

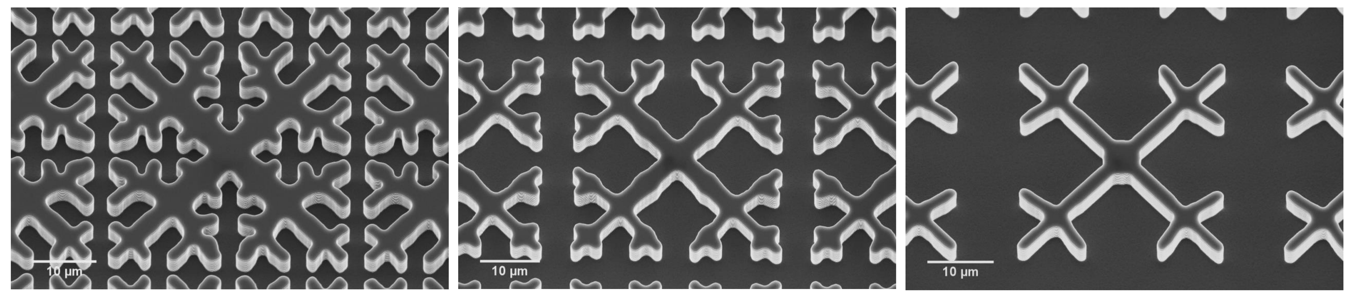


Spinning of photoresist.

Standard UV-Lithography, consisting of UV exposure and development.

Pattern transfer by D-RIE etch, followed by removal of remaining photoresist.

Silicon structures are coated with FDTS to create a hydrophobic surface.

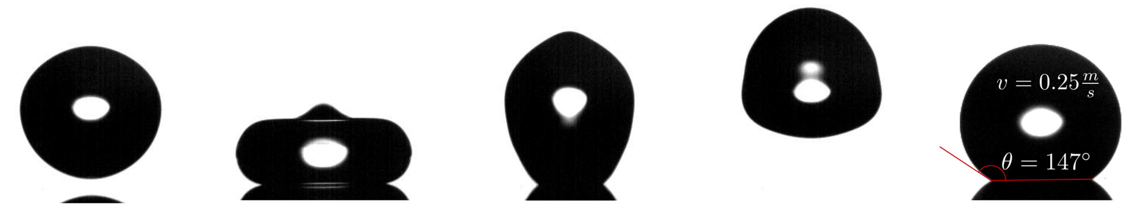


SEM images of some of the produced structures with varying surface coverage.

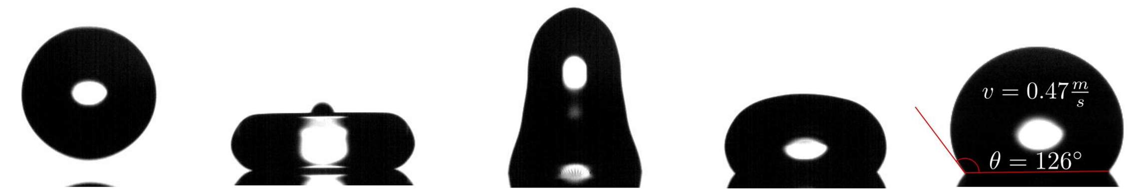
Characterization

Impact Measurements

The effect of applied pressure have been tested by dropping a water drop from different heights. The different velocities results in different dynamic pressures.

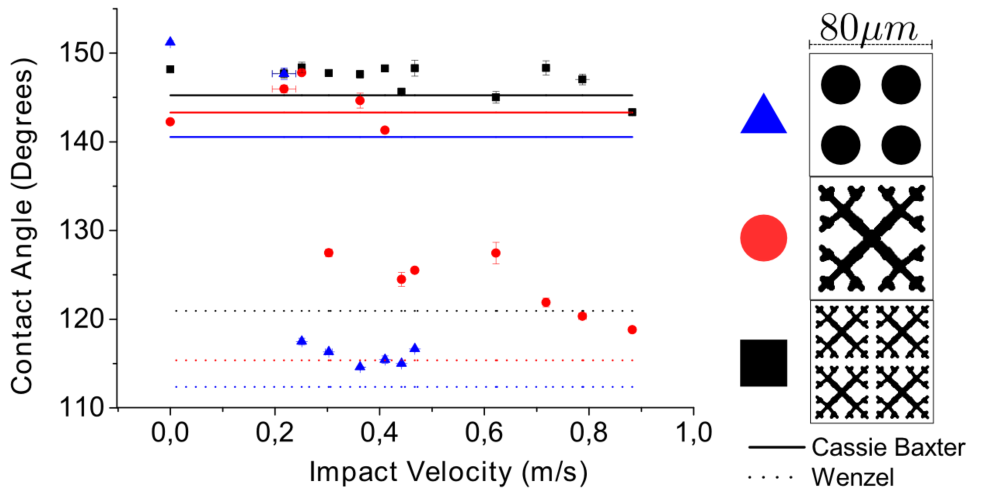


Impact with low velocity. The drop does not pin during the impact.



Impact with high velocity. The drop does pin during the impact.

Impact Results



The topology optimized design shows improved stability of the Cassie-Baxter state during impact, when compared to circular pillars of the same lattice constant.

Contact angles measurement after different impact velocities. Measurements showing contact angles below 135 degrees are pinned on the microstructures.